By FREDERICK G. KAPPLER and GARY L. RUTLEDGE

Stock of Plant and Equipment for Air and Water Pollution Abatement in the United States, 1960–81

THIS article introduces annual estimates of the stock of nonfarm business plant and equipment (P&E) for air and water pollution abatement (PA) in the United States for 1960–81 (chart 1). This stock consists of fixed reproducible tangible capital (except motor vehicle emission abatement devices) owned by nonresidential nonfarm business and employed in the abatement of air and water pollutant emissions.[1] Both gross and net stock estimates are presented, valued at constant cost and at current cost. The PA P&E stock estimates are useful in interpreting economic performance measures—output, productivity, and price change as conventionally measured and aggregate economic well-being as variously defined—and in modeling economic behavior utilizing these measures. Analyses of these kinds often involve separating the PA P&E stock from that of conventional capital.

Constant-cost stock estimates value identical assets at the same price (in this article, the 1972 price) regardless of their actual prices in their year of acquisition (i.e., historical prices). These constant-cost estimates are referred to as "real" estimates in this article. Current-cost stock estimates value assets at prices that would have been paid for them if they had been produced in the year to which the stock estimates refer.[2]

Annual estimates of the stock of PA P&E are derived from PA P&E expenditures using the perpetual inventory method. The PA P&E expenditures estimates for 1960–81 are shown in this article.[3] They are of interest in their own right, and, as well, facilitate the interpretation of the stock estimates.

Highlights of the article are:

- The real gross stock of nonfarm business air and water PA P&E at yearend 1981 was $56.6 billion, 2.8 percent of the real gross stock of all fixed nonresidential nonfarm business capital.
- The real gross stock of nonfarm business air and water PA P&E increased at an average annual rate of 13 percent during 1960–81, compared with an average annual increase of only 4 percent for the real gross stock of fixed nonresidential nonfarm business capital excluding PA P&E.
- Real spending for air and water PA P&E—which determines the growth of the gross stock of PA P&E—grew at an average annual rate of 11 percent during 1960–81, compared with 4 percent for P&E spending excluding PA.

The first section of this article focuses on real estimates of nonfarm business air and water PA P&E (referred to as PA P&E unless otherwise noted). Growth rates of PA P&E stocks and expenditures for 1960–81 are examined. A subsection on industry trends relates growth rates of stocks to those for expenditures for PA P&E and for P&E excluding PA. The second section briefly discusses current-cost stock estimates. The methodology used in estimating stocks is summarized in the final section and detailed in the technical notes. Major elements of the context in which the rapid growth in the gross stock of PA P&E occurred are summarized in the box accompanying the article (p. 22).

Real Stock

The real gross stock of PA P&E at yearend 1981 was $56.6 billion, two-thirds, or $37.8 billion, in manufacturing industries and one-third, or $18.8 billion, in nonmanufacturing (table 1). The total was 2.8 percent of the real gross stock of all fixed nonresidential non-farm business capital (hereinafter referred to as business capital).[4] In

NOTE.—The stock series presented in this article represent several years' research. Frederick J. Dreiling conducted the early phases. Gerald Silverstein provided advice during the later phases. Richard J. Martucci did the computer programming, and Tracy K. Leigh and Saundria W. Carter provided statistical assistance.

1. Although stock estimates for air PA P&E and for water PA P&E are not shown separately in this article, the definition of PA P&E is the same as that used in Gary L. Rutledge and Betsy D. O'Connor, "Plant and Equipment Expenditures by Business for Pollution Abatement, 1981 and Planned 1982," SURVEY OF CURRENT BUSINESS, 62 (June 1982): 17–21 and 72. Plant and equipment for solid waste collection and disposal by means acceptable to Federal, State, and local authorities are excluded from the estimates in the present article due to deficiencies in source data.

Pollution abatement is the reduction or elimination of emissions of pollutants that is brought about by human activity directed to that purpose. Pollutants are defined as substances and other emissions (e.g., noise) that degrade the quality of common-property media (e.g., the atmosphere).

Fixed reproducible tangible capital consists of equipment and structures owned by business, government and government enterprises, and households and institutions. For further information, see U.S. Department of Commerce, Bureau of Economic Analysis (BEA), *Fixed Reproducible Tangible Wealth in the United States, 1925–79*, pp. T-1 through T-40. The present article discusses the PA portion of fixed reproducible tangible capital owned by nonfarm nonresidential business.

2. For example, the 1981 stock at current cost values assets at 1981 prices and the 1980 stock values assets at 1980 prices.

3. Expenditures estimates for PA P&E for 1973–81 are from the BEA survey on new P&E expenditures. See Rutledge and O'Connor, "Plant and Equipment," p. 18. The estimates for years prior to 1973 were developed from a variety of data sources, discussed later. The scarcity of sources prior to 1967 adversely affects the quality of the estimates.

4. The denominator of the percentage given is a tentative estimate; published estimates of the real gross stock of business capital are for 1925–79 only. See BEA, *Fixed Reproducible Tangible Wealth*, pp. T-1 through T-40 and 1, 4, 55, and 58. The real gross stock of business capital is derived from investment series that are part of the national income and product accounts. For a summary of differences in definition be-

1981, the real gross stock of PA P&E was 14 times its size in 1960.

The difference between the gross and net stock is accumulated depreciation, i.e., the portion of the gross stock's value lost through physical deterioration and obsolescence.[5] The real net stock of PA P&E at yearend 1981 was $38.1 billion, $24.0 billion in manufacturing and $14.0 billion in nonmanufacturing (table 2). The total was 3.3 percent of the real net stock of all business capital. In 1981, the value of the real net stock of PA P&E was 10 times its size in 1960.

The real gross stock of PA P&E increased at an average annual rate of 13 percent during 1960–81 (table 3). It increased at an 18-percent annual rate during 1970–75, when the stimulus of Federal legislation was strongest (see accompanying box). In contrast, the real gross stock of business capital excluding PA P&E increased at an average annual rate of 4 percent during 1960–81 and at the same rate during 1970–75 (table 4). The net stock of PA P&E increased at an average annual rate of 11 percent during 1960–81, and at 19 percent during 1970–75. Growth rates for the net stock of business capital excluding PA P&E were 4 percent and 3 percent, respectively, for these periods.

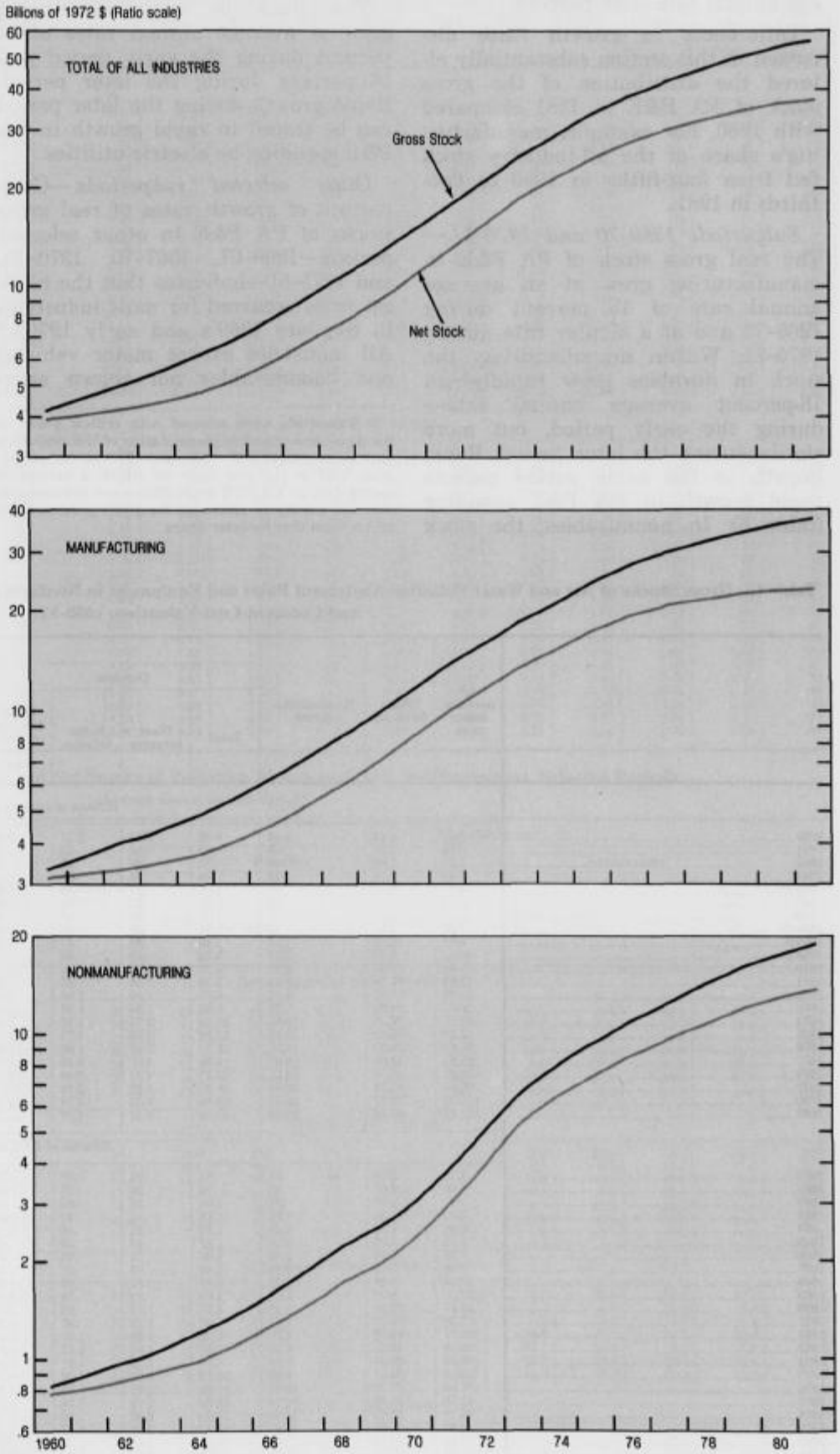
Relatively large growth rates in stocks of PA P&E are traceable to trends in PA P&E spending. Real spending for PA P&E grew at an average annual rate of 11 percent during 1960–81 and 15 percent during 1970–75 (tables 5 and 6). Real spending for P&E excluding PA grew at a rate of 4 percent and less than 1 percent, respectively.

Industry trends

The real gross stock of PA P&E in manufacturing grew at an average annual rate of 12 percent during 1960–81. Within manufacturing, the stock in durables grew more rapidly

CHART 1

Gross and Net Stocks of Pollution Abatement Plant and Equipment



U.S. Department of Commerce, Bureau of Economic Analysis

82-11-1

tween new P&E expenditures and national income and product account estimates of investment, see George R. Green and Marie P. Hertzberg, "Revised Estimates of New Plant and Equipment Expenditures in the United States, 1947–77," SURVEY 60 (October 1980): 24–59. No adjustments for differences in definition were made to PA P&E stocks in comparing them with stocks of business capital.

5. Depreciation, as estimated when deriving the net stock, also includes value lost due to some accidental damage but excludes large-scale (i.e., disaster) damage.

than in nondurables. The stock in nonmanufacturing grew at an average annual rate of 16 percent.

Differences in growth rates discussed in this section substantially altered the distribution of the gross stock of PA P&E in 1981 compared with 1960. For example, manufacturing's share of the all-industry stock fell from four-fifths in 1960 to two-thirds in 1981.

Subperiods 1960–70 and 1970–81.—The real gross stock of PA P&E in manufacturing grew at an average annual rate of 13 percent during 1960–70 and at a similar rate during 1970–81. Within manufacturing, the stock in durables grew rapidly—an 18-percent average annual rate—during the early period, but more slowly during the later period. Rapid growth in the early period reflects rapid growth in PA P&E spending (table 6). In nondurables, the stock grew at a rate of 11 percent during both subperiods.

The stock in nonmanufacturing grew at average annual rates of 14 percent during the early period and 18 percent during the later period. Rapid growth during the later period can be traced to rapid growth in PA P&E spending by electric utilities.

Other selected subperiods.—Comparison of growth rates of real gross stocks of PA P&E in other selected periods—1960–67, 1967–70, 1970–75, and 1975–81—indicates that the highest rates occurred for most industries in the late 1960's and early 1970's.[6] All industries except motor vehicles and "nondurables not shown separately" had higher growth rates during 1967–70 than during 1960–67; high growth rates for the stocks for most industries continued during 1970–75.

Growth rates of industry spending for PA P&E are themselves influenced by growth rates of P&E spending (excluding PA), because PA and other capital are complementary goods.[7] Moderate growth rates of P&E spending by most industries boosted growth rates in PA P&E spending during 1960–67 relative to other periods; low and negative rates of P&E spending dampened rates of PA P&E spending during 1967–70 and during 1970–75. Despite widespread boosts from P&E spending, PA P&E spending fell during 1975–81.

6. Subperiods were selected with critical years in the development and implementation of U.S. pollution abatement policy (1967, 1970, and 1975) as end points. Also, 1967 is the first year for which a variety of source data on PA P&E expenditures are available, so that the quality of estimates for years prior to 1967 differs from that for later years.

7. Spending for PA normally accompanies that for production facilities and fluctuates with P&E spending; however, the two types of spending are not perfect complements and the mix of the two types purchased varies over time with changes in PA programs.

Table 1.—Gross Stocks of Air and Water Pollution Abatement Plant and Equipment in Nonfarm Business, by Major Industry Group, Current-Cost and Constant-Cost Valuation, 1960–81

	All nonfarm industries	Manufacturing	Nonmanufacturing	Manufacturing: Durables: Total	Durables: Blast furnaces	Durables: Motor vehicles	Durables: Durables not shown separately	Manufacturing: Nondurables: Total	Nondurables: Chemicals	Nondurables: Petroleum	Nondurables: Paper	Nondurables: Food including beverages	Nondurables: Nondurables not shown separately
	Billions of current dollars												
1960	2.02	2.44	0.58	0.62	0.16	0.21	0.25	1.82	0.64	0.65	0.19	0.13	0.02
1961	2.78	2.60	.63	.63	.18	.23	.27	1.97	.60	.82	.20	.14	.02
1962	2.58	2.88	.69	.70	.29	.28	.31	2.13	.75	1.00	.22	.15	.02
1963	3.02	3.16	.76	.86	.23	.29	.34	2.30	.81	1.07	.24	.16	.03
1964	4.27	3.62	.85	1.01	.27	.33	.40	2.61	.88	1.16	.26	.18	.03
1965	5.60	4.61	.99	1.21	.32	.39	.50	2.80	.98	1.27	.30	.19	.05
1966	6.89	4.71	1.18	1.51	.39	.46	.65	3.20	1.11	1.44	.35	.22	.06
1967	7.67	5.63	1.44	1.91	.49	.52	.90	3.73	1.29	1.68	.42	.24	.12
1968	8.61	6.82	1.78	2.46	.62	.57	1.27	4.37	1.49	1.84	.51	.27	.15
1969	10.62	8.49	2.19	3.22	.79	.64	1.78	5.21	1.73	2.20	.64	.35	.19
1970	13.42	10.61	2.81	4.25	1.02	.77	2.46	6.36	2.02	2.74	.83	.47	.30
1971	17.01	13.26	3.74	5.36	1.24	.90	3.22	7.91	2.40	3.47	1.05	.63	.36
1972	21.37	16.25	5.12	6.57	1.58	1.04	4.03	9.68	2.92	4.07	1.38	.83	.48
1973	26.25	20.72	7.53	8.66	1.82	1.28	5.56	12.05	3.65	4.93	1.80	1.14	.64
1974	35.97	28.45	10.53	11.33	2.27	1.53	7.43	15.22	4.41	6.06	2.27	1.50	.80
1975	45.28	33.02	13.26	13.85	2.56	1.72	9.31	19.13	5.45	7.70	3.02	1.89	1.07
1976	55.82	39.32	16.50	15.37	3.49	1.88	11.00	22.96	6.64	9.15	3.66	2.27	1.25
1977	66.91	46.00	19.91	19.06	4.20	2.10	12.76	26.94	7.88	10.85	4.28	2.66	1.45
1978	78.23	53.76	24.51	22.31	4.97	2.44	14.89	31.55	9.14	12.02	4.88	3.28	1.72
1979	93.05	62.14	30.31	25.07	6.02	2.89	17.15	36.97	10.39	14.21	5.64	3.72	2.00
1980	110.32	73.77	36.56	30.88	7.32	3.54	20.12	42.89	11.88	17.85	6.46	4.35	2.34
1981	128.41	85.78	42.64	35.84	8.41	4.50	23.28	49.93	13.62	21.22	7.32	5.07	2.71
	Billions of 1972 dollars												
1960	4.18	3.85	.32	.84	.21	.28	.35	2.52	.68	1.16	.26	.17	.03
1961	4.55	3.87	.30	.94	.25	.32	.38	2.73	.96	1.29	.28	.19	.02
1962	4.97	4.00	.37	1.04	.28	.35	.42	2.96	1.03	1.38	.30	.21	.03
1963	5.43	4.36	1.07	1.18	.31	.40	.47	3.16	1.12	1.48	.33	.22	.04
1964	6.02	4.82	1.20	1.37	.37	.46	.54	3.45	1.21	1.60	.36	.24	.05
1965	6.75	5.59	1.36	1.62	.43	.53	.66	3.77	1.32	1.72	.41	.26	.07
1966	7.73	6.16	1.56	1.94	.51	.60	.85	4.19	1.45	1.89	.46	.29	.10
1967	8.69	7.15	1.85	2.49	.63	.66	1.13	4.75	1.64	2.11	.53	.30	.15
1968	10.48	8.29	2.19	2.97	.75	.69	1.53	5.32	1.82	2.37	.62	.33	.18
1969	12.30	9.69	2.61	3.68	.91	.74	2.02	6.01	2.00	2.64	.74	.40	.22
1970	14.47	11.46	3.01	4.59	1.11	.83	2.64	6.89	2.20	2.89	.80	.51	.32
1971	17.38	13.57	3.81	6.48	1.27	.92	3.29	8.09	2.46	3.55	1.07	.64	.37
1972	20.77	15.78	4.99	6.80	1.46	1.01	3.32	9.39	2.83	4.05	1.34	.80	.47
1973	24.88	19.28	6.56	7.85	1.61	1.13	4.01	10.68	3.14	4.36	1.59	1.01	.57
1974	29.94	23.91	7.99	8.94	1.79	1.21	5.84	12.11	3.52	4.82	1.80	1.19	.69
1975	33.63	24.25	9.32	10.13	2.00	1.26	6.78	14.12	4.05	5.67	2.23	1.39	.78
1976	38.64	27.22	10.61	11.35	2.41	1.30	7.55	15.96	4.63	6.35	2.54	1.59	.86
1977	42.16	29.90	12.26	12.29	2.72	1.36	8.22	17.51	5.13	6.98	2.78	1.78	.94
1978	45.11	32.85	14.06	13.90	2.96	1.46	8.79	18.95	5.47	7.53	2.91	1.91	1.02
1979	49.91	34.89	15.81	14.12	3.27	1.67	9.22	19.57	5.67	8.11	3.07	2.03	1.09
1980	53.56	36.14	17.41	15.06	3.53	1.79	9.79	21.09	5.88	8.76	3.18	2.14	1.15
1981	56.68	37.79	18.81	15.88	3.69	1.98	10.15	22.11	6.08	9.37	3.24	2.25	1.18

Table 2.—Net Stocks of Air and Water Pollution Abatement Plant and Equipment in Nonfarm Business, by Major Industry Group, Current-Cost and Constant-Cost Valuation, 1960–81

	All nonfarm industries	Manufacturing	Nonmanufacturing	Manufacturing									
				Durables				Nondurables					
				Total	Blast furnaces	Motor vehicles	Durables not shown separately	Total	Chemicals	Petroleum	Paper	Food including beverages	Nondurables not shown separately
	Billions of current dollars												
1960	2.86	2.81	0.56	0.69	0.15	0.20	0.24	1.72	0.60	0.81	0.18	0.12	0.02
1961	2.96	2.88	.58	.62	.16	.21	.25	1.76	.61	.83	.18	.12	.02
1962	3.07	2.98	.61	.65	.17	.23	.26	1.80	.62	.85	.18	.13	.02
1963	3.21	2.98	.65	.71	.19	.25	.28	1.85	.63	.87	.19	.13	.03
1964	3.45	2.74	.71	.81	.22	.28	.31	1.93	.65	.90	.20	.14	.03
1965	3.83	3.02	.81	.95	.25	.32	.38	2.07	.70	.95	.23	.15	.04
1966	4.42	3.47	.95	1.18	.30	.36	.51	2.29	.77	1.03	.25	.16	.07
1967	5.28	4.13	1.14	1.48	.38	.39	.71	2.65	.89	1.18	.31	.17	.10
1968	6.49	4.99	1.41	1.91	.47	.42	1.02	3.08	1.03	1.38	.38	.19	.13
1969	7.89	6.19	1.71	2.51	.60	.47	1.43	3.67	1.20	1.56	.46	.25	.17
1970	10.09	7.88	2.20	3.34	.78	.54	2.02	4.54	1.41	1.90	.63	.35	.25
1971	12.89	9.92	2.97	4.19	.98	.68	2.53	5.73	1.70	2.45	.79	.47	.33
1972	16.81	12.16	4.15	5.09	1.12	.71	3.26	7.07	2.07	2.89	1.06	.64	.40
1973	21.69	15.46	6.21	6.69	1.34	.97	4.48	8.79	2.61	3.46	1.29	.90	.53
1974	28.27	19.63	8.65	8.67	1.63	1.02	5.92	11.06	3.10	4.27	1.51	1.17	.70
1975	35.13	24.35	10.78	10.44	2.06	1.11	7.26	13.91	3.85	5.47	2.38	1.40	.85
1976	41.67	28.57	13.11	12.08	2.61	1.17	8.35	16.53	4.69	6.44	2.72	1.74	.97
1977	48.66	32.74	15.92	13.65	2.88	1.30	9.37	19.09	5.60	7.41	3.08	2.06	1.18
1978	56.43	37.20	19.23	15.42	3.45	1.49	10.47	21.78	6.22	8.59	3.35	2.35	1.26
1979	65.72	42.22	23.50	17.58	4.12	1.79	11.67	24.64	6.84	9.96	3.74	2.67	1.42
1980	76.20	48.32	27.88	20.25	4.83	2.23	13.19	28.07	7.59	11.73	4.12	3.08	1.59
1981	86.18	54.88	31.29	22.64	5.42	2.64	14.59	31.74	8.45	13.51	4.45	3.42	1.79
	Billions of 1972 dollars												
1960	3.97	3.19	.78	.80	.20	.27	.33	2.39	.83	1.12	.25	.17	.02
1961	4.12	3.30	.82	.85	.22	.29	.34	2.45	.85	1.16	.25	.17	.03
1962	4.26	3.41	.87	.90	.24	.31	.35	2.51	.86	1.16	.26	.18	.03
1963	4.47	3.55	.92	.98	.26	.34	.38	2.57	.87	1.21	.27	.19	.03
1964	4.77	3.78	1.00	1.10	.30	.38	.43	2.66	.90	1.24	.28	.20	.04
1965	5.19	4.08	1.11	1.28	.34	.43	.51	2.80	.95	1.28	.31	.20	.06
1966	5.82	4.58	1.27	1.53	.39	.47	.67	3.02	1.02	1.36	.34	.21	.09
1967	6.74	5.38	1.53	1.87	.48	.50	.89	3.38	1.14	1.50	.40	.22	.13
1968	7.82	6.08	1.74	2.31	.57	.51	1.23	3.77	1.26	1.65	.46	.23	.16
1969	9.08	7.12	1.96	2.88	.70	.54	1.64	4.25	1.39	1.82	.55	.29	.19
1970	10.09	8.52	2.96	3.60	.85	.58	2.17	4.93	1.53	2.06	.69	.38	.28
1971	13.18	10.15	3.03	4.28	.96	.64	2.69	5.87	1.74	2.52	.81	.48	.31
1972	15.85	11.81	4.04	4.95	1.09	.69	3.17	6.86	2.01	2.81	1.03	.62	.38
1973	19.10	13.70	5.40	5.91	1.18	.77	3.96	7.78	2.32	3.06	1.23	.79	.47
1974	22.13	15.58	6.55	6.76	1.29	.81	4.66	8.81	2.48	3.40	1.44	.93	.56
1975	25.48	17.91	7.57	7.62	1.51	.81	5.30	10.28	2.86	4.03	1.68	1.06	.65
1976	28.50	19.80	8.70	8.29	1.74	.81	5.74	11.51	3.27	4.47	1.88	1.21	.67
1977	31.06	21.24	9.82	8.81	1.90	.84	6.04	12.42	3.60	4.82	2.00	1.30	.71
1978	33.23	22.19	11.03	9.17	2.06	.89	6.22	13.02	3.73	5.13	2.01	1.41	.75
1979	35.22	22.97	12.26	9.53	2.24	.97	6.32	13.44	3.74	5.43	2.04	1.46	.77
1980	37.00	23.72	13.28	9.86	2.36	1.09	6.43	13.86	3.75	5.77	2.04	1.50	.79
1981	38.07	24.03	14.04	9.93	2.38	1.16	6.39	14.10	3.77	6.04	1.99	1.52	.78

Table 3.—Growth Rates for Gross and Net Stocks of Pollution Abatement Plant and Equipment, Selected Periods

(Average annual percent change)

	All nonfarm industries	Manufacturing	Nonmanufacturing	Manufacturing									
				Durables				Nondurables					
				Total	Blast furnaces	Motor vehicles	Durables not shown separately	Total	Chemicals	Petroleum	Paper	Food including beverages	Nondurables not shown separately
	Gross stocks (Valued in current dollars)												
1960–1981	19.6	18.5	22.7	21.3	21.9	15.4	23.9	17.1	15.7	16.5	15.1	19.3	27.8
1960–1970	16.1	15.8	17.1	21.2	20.9	13.9	25.3	13.8	12.2	12.4	16.1	14.2	34.1
1960–1967	12.9	12.7	13.9	17.4	18.1	13.8	19.5	10.8	10.6	10.0	12.2	9.7	33.4
1967–1970	23.8	23.5	25.1	30.6	27.5	14.1	40.0	19.5	16.2	19.1	25.9	25.5	38.7
1970–1981	22.3	20.9	28.1	21.4	21.1	18.7	22.7	20.6	18.9	20.4	21.5	24.1	22.3
1970–1975	28.1	25.5	35.4	26.7	22.8	17.5	30.5	24.6	22.0	22.9	29.4	31.9	29.3
1975–1981	18.5	17.2	21.5	17.1	19.7	16.1	16.4	17.3	16.4	18.4	16.9	18.8	16.9
	(Valued in 1972 dollars)												
1960–1981	13.2	12.2	16.1	14.9	14.6	9.3	17.4	10.9	8.6	10.4	12.7	13.0	20.9
1960–1970	13.2	13.0	13.9	18.4	18.0	11.2	22.5	10.6	9.5	9.6	13.2	11.4	30.7
1960–1967	11.6	11.4	12.4	16.1	16.8	12.5	18.3	9.5	9.3	8.7	10.5	8.8	31.6
1967–1970	17.1	17.0	17.5	24.0	23.9	8.3	32.9	15.2	10.1	11.9	19.1	18.5	28.5
1970–1981	13.3	11.5	18.1	12.8	11.6	7.6	13.9	11.2	9.7	11.0	12.9	14.4	12.7
1970–1975	15.8	16.2	24.4	17.2	13.6	6.8	20.7	15.5	13.1	13.9	19.8	22.2	13.1
1975–1981	9.1	7.7	12.4	7.6	8.9	8.6	7.9	7.6	7.9	8.7	8.4	8.4	7.2
	Net stocks (Valued in current dollars)												
1960–1981	17.6	16.2	21.3	19.0	18.6	13.1	21.5	14.5	13.4	14.4	16.6	17.9	25.5
1960–1970	13.4	13.1	14.5	18.9	18.2	10.4	23.6	10.2	9.9	9.8	13.6	11.4	32.6
1960–1967	9.1	8.7	10.3	14.1	14.6	10.1	16.5	6.4	6.8	5.5	8.3	5.4	31.8
1967–1970	24.1	24.0	24.4	31.2	27.2	10.9	41.8	19.7	16.6	17.3	26.9	26.6	34.6
1970–1981	21.5	18.2	27.5	19.0	18.2	15.6	19.7	19.3	17.7	19.5	18.4	23.0	19.3
1970–1975	28.9	25.3	37.4	25.6	21.3	15.6	29.2	25.1	22.2	23.6	29.8	33.0	27.4
1975–1981	16.1	14.3	19.8	13.8	17.5	15.5	12.3	14.7	14.0	16.5	11.8	15.3	13.0
	(Valued in 1972 dollars)												
1960–1981	11.4	10.1	14.7	12.7	12.5	7.1	15.2	8.8	7.5	8.3	10.4	11.1	18.8
1960–1970	10.6	10.3	11.6	16.2	15.4	7.8	20.8	7.5	6.3	6.2	10.7	8.6	29.3
1960–1967	7.8	7.4	8.5	12.9	13.3	8.9	16.4	6.3	4.8	4.3	6.9	4.1	30.1
1967–1970	17.3	17.5	16.9	24.4	20.6	6.2	34.6	13.3	10.3	11.9	20.0	19.5	27.3
1970–1981	12.1	9.9	17.6	9.7	9.8	6.8	10.3	10.0	9.5	10.3	10.1	13.5	10.0
1970–1975	18.5	16.0	25.2	16.2	12.2	7.1	19.6	15.9	13.3	14.4	19.7	23.3	17.9
1975–1981	6.9	5.0	10.9	4.5	7.9	6.1	3.2	5.4	4.7	7.0	2.8	5.9	3.7

NOTE.—Growth rates are calculated from estimates in tables 1 and 2. See footnote 6 for an explanation of the subperiods chosen.

Stock Valued at Current Cost

The gross stock of PA P&E valued at current cost at yearend 1981 was $128.4 billion, $85.8 billion in manufacturing and $42.6 billion in nonmanufacturing. The total was 2.8 percent of the gross stock of all business capital.

During 1960–81, the current-cost gross stock of PA P&E grew at an average annual rate of 20 percent. The gross stock of other business capital grew at one-half that rate. Although price changes for PA P&E and for other business capital were similar during this period, only one-third of the growth rate in the stock of PA P&E was due to price change, whereas most of the growth rate in the stock of other business capital was due to price change.

The current-cost net stock of PA P&E at yearend 1981 was $86.2 billion, $54.4 billion in manufacturing and $31.8 billion in nonmanufacturing. The total was 3.3 percent of the net stock of all business capital.

During 1960–81 the current-cost net stock grew at an average annual rate of 18 percent, compared with 10 percent for the net stock of other business capital. The effect of price change on growth rates of net stocks was similar to that for gross stocks.

Summary Methodology

Gross stocks of PA P&E by industry were estimated using the perpetual inventory method. In the method, past investment is cumulated and discards are deducted in accordance with the lifetimes of capital goods. Net stocks are calculated by subtracting accumulated depreciation from gross stocks to reflect the decrease in the usefulness of existing capital.

The perpetual inventory method requires three data elements:

(1) Current-dollar capital spending over an extended period, or, in the absence of an extended series, the initial capital stock;

(2) Price indexes; and

(3) Lifetimes of assets, or, in the absence of detail on lifetimes, average lifetimes and typical retirement patterns.

Estimates of PA P&E spending are available for 1973–81 from BEA's survey on new P&E expenditures. Initial stocks by industry in 1959 of PA P&E were developed from several sources; the most important was a survey by the National Association of Manufacturers (NAM). The linking of the 1959 information to that for 1973 was done in two steps. Spending in 1973 was extrapolated back to 1967 using similar spending estimates from trade associations and the McGraw-Hill Publications Company. Second, PA P&E spending for 1960–66 was estimated by multiplying total P&E spending each year by the 1959 stock ratio of PA P&E to total P&E.[8]

Price indexes were developed using components of the Bureau of Labor

8. This stock ratio was assumed to equal the ratio of PA P&E spending to total P&E spending for 1960–66. The ratio of spending probably remained constant until the mid-1950's.

Growth in the Stock of Plant and Equipment for Pollution Abatement: The Context

With the extensions of the series on plant and equipment for pollution abatement presented in this article, the stock and expenditure series begin in 1959. That year roughly dates the beginning of the period in which pollution abatement spending became a significant enough issue to warrant the collection of national data related to it. The context in which the rapid growth in the stock, as described in the article, occurred is complex, but a 20-year period provides perspective that helps delineate the major elements. Among these elements are:

—The political process by which decisions about pollution abatement were made was put in motion by an economic problem: how to provide increased collective consumption of clean air and water not voluntarily forthcoming or directly purchasable.

—The increased demand for clean air and water first took the form of controversy over the importance of reducing pollution between U.S. business, on the one hand, and citizens and their governments at all levels, on the other. The prevalence and intensity of controversy increased dramatically in the 1960's.

—The increased demand for clean air and water is traceable to several interrelated factors. Among them are: (1) the widespread perception that the magnitude of the pollution problem was growing rapidly; (2) heightened public awareness of pollution, stemming from well-publicized environmental disruptions such as oil spills, severe smog, and releases of dangerous chemicals, and from increasing scientific knowledge of, and capability for measuring, health hazards; and (3) rising real income (i.e., disposable personal income per capita), which affected political and economic priorities. Specifically, rising real income boosted demand for clean air and water as well as private goods that were most income elastic.

—High growth rates of real PA P&E spending, especially after 1965, indicate that many businesses responded relatively quickly to concern about pollution by undertaking or enlarging pollution abatement programs. Underlying this response was the growing acceptance of their necessary role as primary providers of clean air and water. In part, this response was stimulated by the growing political power of environmental groups and spreading support for environmental causes.

—The political process in which business, government, and the public engaged to resolve the economic problem led to the formulation and evolution of policies at all levels of government. The Federal role in pollution abatement policy formation grew throughout the 1960's. It became dominant with the passage of the Clean Air Act Amendments of 1970 and the Water Pollution Control Act Amendments of 1972. These amendments constituted the largest increase in legislated requirements for pollution abatement during the 1960–81 period.

Statistics Producer Price Index, the *Chemical Engineering* Plant Cost Index, the Environmental Protection Agency (EPA) Large City Advanced Wastewater Treatment Plant Cost Index, and the Handy-Whitman Index of Public Utility Construction Costs. Indexes were calculated separately for air and for water PA P&E spending, for manufacturing, electric utilities, and nonmanufacturing (excluding electric utilities).

Estimates of lifetimes by industries for air and for water PA facilities were obtained by consulting with industry specialists and trade groups. The retirement pattern assumed was the modified Winfrey S-3 retirement pattern used in BEA's estimates of business capital.[9]

Table 4.—Growth Rates for Gross and Net Stocks of Fixed Nonresidential Nonfarm Business Capital (Excluding Pollution Abatement Plant and Equipment), Selected Periods

[Average annual percent change]

	Gross stock		Net stock	
	Valued in current dollars	Valued in 1972 dollars	Valued in current dollars	Valued in 1972 dollars
1964–81	9.8	3.0	9.9	4.0
1960–1970	7.2	4.1	7.8	4.8
1960–1967	5.7	3.9	6.0	4.7
1967–1970	10.8	4.6	11.2	4.9
1970–1981	12.3	2.7	11.8	3.2
1970–1976	12.4	3.8	12.0	3.5
1976–1981	12.2	3.5	11.6	3.0

Technical Notes

These technical notes describe the sources and procedures used in estimating gross and net stocks of PA P&E and are organized according to the three data elements required by the perpetual inventory method.

9. BEA, *Fixed Reproducible Tangible Wealth*, p. T–23.

1. Stock in 1959 and spending during 1960–81

The earliest data useful in estimating the PA P&E stock are for manufacturing only and are from a survey by NAM (*Water In Industry*, New York: National Association of Manufacturers, 1965). Sample data from this survey of the gross stock (valued at current cost in 1959) of waste water treatment facilities were increased to a total (i.e., universe) level using ratios of sample to universe data for a reference variable (e.g., water treated prior to discharge or plant production capacity). Data for construction of industry sample-to-universe ratios are either from NAM (*Water In Industry*) or the Census Bureau (*United States Census of Manufactures, 1958*, vol. I., *Summary Statistics*, pt. 11, Industrial Water Use).

For manufacturing, the air PA P&E stocks by industry in 1959 were estimated as the water PA P&E stocks in 1959 multiplied by air-to-water ratios

Table 5.—Expenditures for Air and Water Pollution Abatement New Plant and Equipment in Nonfarm Business, by Major Industry Group, in Current and Constant Dollars, 1960–81

Year	All nonfarm industries	Manufacturing	Nonmanufacturing	Manufacturing: Durables: Total	Durables: Blast furnaces	Durables: Motor vehicles	Durables: Durables not shown separately	Manufacturing: Nondurables: Total	Nondurables: Chemicals	Nondurables: Petroleum	Nondurables: Paper	Nondurables: Food including beverages	Nondurables: Nondurables not shown separately
	Billions of current dollars												
1960	0.23	0.24	0.05	0.09	0.04	0.03	0.02	0.15	0.05	0.07	0.02	0.01	0
1961	.27	.22	.05	.07	.03	.02	.02	.15	.05	.07	.01	.01	0
1962	.29	.23	.06	.09	.02	.03	.03	.16	.05	.07	.02	.01	0
1963	.33	.26	.07	.10	.03	.03	.04	.17	.06	.07	.02	.01	0
1964	.43	.34	.09	.14	.04	.04	.06	.20	.07	.08	.02	.01	.01
1965	.55	.44	.12	.18	.05	.06	.08	.25	.10	.09	.03	.01	.01
1966	.76	.60	.16	.26	.08	.05	.13	.33	.11	.13	.04	.02	.03
1967	1.04	.82	.21	.35	.09	.04	.22	.48	.16	.19	.05	.02	.04
1968	1.25	.98	.27	.46	.10	.03	.33	.52	.18	.22	.06	.02	.02
1969	1.55	1.23	.32	.62	.14	.03	.43	.56	.20	.25	.11	.01	.04
1970	2.22	1.75	.47	.83	.19	.03	.58	.82	.23	.34	.16	.10	.09
1971	2.95	2.17	.78	1.09	.16	.10	.83	1.28	.33	.40	.17	.13	.05
1972	3.69	2.61	1.09	1.36	.20	.10	.96	1.46	.42	.40	.22	.17	.10
1973	4.61	2.62	1.69	1.39	.19	.13	1.07	1.23	.41	.50	.30	.23	.11
1974	6.30	3.45	1.81	1.53	.24	.11	1.18	1.97	.53	.50	.37	.23	.14
1975	8.69	4.69	1.89	1.81	.43	.08	1.30	2.68	.78	1.21	.48	.27	.14
1976	6.78	4.54	2.24	1.91	.49	.08	1.14	2.64	.92	1.06	.47	.28	.11
1977	6.84	4.80	2.48	1.80	.50	.13	1.06	2.68	.87	1.40	.40	.26	.12
1978	7.02	4.12	2.90	1.62	.45	.16	1.00	2.50	.90	1.11	.26	.21	.14
1979	7.71	4.40	3.31	1.57	.41	.25	1.00	2.53	.50	1.25	.36	.28	.12
1980	8.35	4.97	3.38	2.11	.60	.37	1.15	2.80	.94	1.28	.32	.25	.13
1981	8.61	4.70	3.92	1.78	.47	.31	1.00	3.01	.74	1.61	.27	.27	.11
	Billions of 1972 dollars												
1960	.39	.39	.06	.12	.05	.03	.03	.21	.06	.09	.02	.01	0
1961	.38	.31	.07	.10	.03	.03	.03	.21	.06	.10	.02	.02	0
1962	.41	.32	.08	.10	.03	.03	.04	.22	.06	.10	.02	.02	0
1963	.45	.36	.10	.13	.04	.04	.05	.23	.06	.10	.03	.02	.01
1964	.60	.47	.13	.15	.05	.06	.08	.28	.10	.11	.03	.02	.01
1965	.76	.60	.16	.26	.06	.07	.12	.34	.13	.13	.05	.02	.02
1966	1.01	.76	.22	.35	.07	.07	.20	.44	.16	.18	.06	.03	.03
1967	1.35	1.06	.29	.45	.12	.06	.28	.62	.21	.25	.08	.03	.05
1968	1.57	1.23	.34	.58	.13	.04	.41	.66	.23	.27	.10	.03	.03
1969	1.83	1.51	.32	.73	.10	.07	.56	.78	.24	.30	.13	.07	.04
1970	2.47	1.95	.52	.92	.20	.07	.65	1.02	.26	.38	.18	.11	.10
1971	3.08	2.27	.81	.93	.17	.10	.66	1.34	.34	.53	.18	.13	.05
1972	3.69	2.61	1.09	1.36	.20	.10	.96	1.46	.42	.49	.22	.17	.10
1973	4.37	2.77	1.60	1.32	.18	.13	1.01	1.45	.38	.47	.28	.21	.10
1974	4.35	2.80	1.45	1.20	.20	.09	.97	1.63	.44	.55	.31	.19	.12
1975	4.89	3.03	1.26	1.35	.32	.06	.97	2.18	.60	.91	.35	.21	.10
1976	4.79	3.25	1.54	1.31	.35	.06	.81	2.04	.60	.76	.34	.20	.08
1977	5.62	2.93	1.58	1.13	.33	.07	.71	1.80	.56	.76	.27	.17	.08
1978	5.32	2.57	1.74	1.01	.28	.11	.62	1.56	.43	.63	.16	.13	.08
1979	5.32	2.50	1.82	1.06	.25	.15	.66	1.44	.32	.71	.20	.13	.07
1980	4.26	2.68	1.58	1.09	.21	.13	.69	1.48	.33	.79	.17	.13	.07
1981	3.69	2.22	1.47	.82	.21	.15	.46	1.39	.34	.76	.13	.12	.06

of PA P&E cumulative spending (or, in a few cases, stocks). Data for these ratios are for selected years prior to 1973, and were obtained from several manufacturing companies, trade associations, and McGraw-Hill.

For nonmanufacturing, stocks by industry of PA P&E in 1959 were estimated as manufacturing stocks in 1959 multiplied by nonmanufacturing-to-manufacturing ratios of cumulative PA P&E spending for 1967–69. The results were allocated to air and water PA, respectively, using air-to-water ratios of cumulative PA P&E spending for 1970–71.

The stocks (for manufacturing and nonmanufacturing industries) in 1959 derived as indicated above were valued, like the NAM sample data, at current cost in 1959 (referred to by NAM as replacement cost). This valuation basis allows 1959 stocks to be treated in calculations of later stocks like initial investments in PA P&E. BEA's calculations linked information for 1959 to that for 1973 in two steps: spending for 1960–66, and spending for 1967–72. Data on PA P&E spending for 1960–66 are unavailable for most industries, and spending was estimated as total P&E spending each year multiplied by the 1959 stock ratio of PA P&E to total P&E. Numerators for the stock ratios, by industry, are 1959 PA P&E stock estimates; denominators are Internal Revenue Service data on gross book value of depreciable assets of corporations as of December 31, 1959. When the assumption of a constant relationship between PA P&E spending and total P&E spending for 1960–66 was not supportable, the ratio of spending was estimated to increase.

For the steel, paper, and petroleum industries, fragmentary data are available prior to 1967. For the steel industry, data on cumulative spending for 1951–65 for air and for water PA P&E are available from the American Iron and Steel Institute (Steel Institute); beginning in 1966, annual spending data are available from this source. To obtain annual spending before 1966, cumulative spending for air and for water PA, respectively, were divided by cumulative total P&E spending for 1951–65; the resulting ratios (air and water) were multiplied by total P&E spending in each year. For paper, additional data on the stocks of water PA P&E in 1963 and 1965 are available from the National Council of the Paper Industry for Air and Stream Improvement (Paper Council). For petroleum, PA P&E spending for 1966 is available from the American Petroleum Institute (Petroleum Institute).

PA P&E spending estimates for 1967–72 are extrapolations back to 1967 from 1973. The extrapolations were based on PA P&E spending reported by the Ford Motor Company, General Motors Corporation, the Steel Institute, the Paper Council, the Petroleum Institute, and McGraw-Hill; data from these sources begin in 1967 and overlap with BEA data for 1973 forward. For most industries, the ratio of cumulative spending for 1973–80 from BEA data to that from the overlapping data source was multiplied by annual spending before 1973 (on the assumption that definitional and sampling differences between

Table 6.—Growth Rates for Expenditures for Pollution Abatement New Plant and Equipment (PA P&E) and New Plant and Equipment (Excluding PA P&E), Selected Periods

[Average annual percent change]

	All nonfarm industries	Manufacturing	Nonmanufacturing	Manufacturing: Durables: Total	Durables: Blast furnaces	Durables: Motor vehicles	Durables: Durables not shown separately	Manufacturing: Nondurables: Total	Nondurables: Chemicals	Nondurables: Petroleum	Nondurables: Paper	Nondurables: Food including beverages	Nondurables: Nondurables not shown separately
Pollution abatement plant and equipment (Valued in current dollars)													
1960–1981	17.3	15.4	22.4	15.6	12.5	12.7	28.5	15.3	13.2	16.3	14.2	10.5	22.5
1960–1970	22.9	23.1	25.2	25.6	16.6	9.9	48.1	19.7	15.5	17.4	25.0	25.0	43.7
1960–1967	28.4	19.5	24.6	22.4	13.3	8.5	40.4	17.7	17.1	16.0	20.9	0.1	58.7
1967–1970	28.7	28.4	29.9	48.5	24.7	17.8	39.5	24.5	12.4	28.9	35.1	88.4	38.8
1970–1981	12.4	11.6	19.1	7.2	9.9	15.5	5.0	11.4	11.9	16.2	8.2	9.4	2.7
1970–1975	24.3	21.8	32.1	16.8	16.5	5.5	17.3	20.3	27.4	29.9	25.0	21.9	16.3
1975–1981	3.3	.4	8.3	−.2	1.5	24.7	−4.2	.7	−1.0	4.9	−3.0	−.1	−3.2
(Valued in 1972 dollars)													
1960–1981	11.3	9.6	16.1	9.8	6.8	7.0	14.5	9.4	7.5	10.4	8.3	10.6	16.0
1960–1970	20.2	19.6	23.1	23.1	14.8	7.3	37.5	17.2	13.2	15.0	22.3	22.3	46.5
1960–1967	19.3	16.4	23.4	21.4	12.4	5.6	38.5	15.8	16.0	14.9	19.6	5.8	57.1
1967–1970	22.4	22.4	22.6	27.2	18.8	11.5	38.0	18.5	7.0	15.1	28.8	74.8	24.0
1970–1981	3.7	1.2	10.0	−1.1	.4	6.8	−3.0	2.8	2.5	6.3	−3.0	1.9	−5.2
1970–1975	14.7	13.6	21.3	7.9	9.4	−9.2	9.3	16.3	18.0	19.1	15.4	13.0	1.9
1975–1981	−4.8	−7.5	1.4	−7.9	−6.4	14.8	−11.6	−7.2	−8.9	−3.3	−10.0	−8.1	−10.7
Plant and equipment excluding pollution abatement plant and equipment (Valued in current dollars)													
1960–1981	9.3	10.1	8.9	10.0	3.6	9.5	10.9	10.3	10.7	10.9	10.8	8.8	9.4
1960–1970	7.9	8.1	7.6	6.8	1.1	7.5	10.3	7.5	7.5	5.6	7.7	9.2	9.0
1960–1967	7.9	10.0	6.8	11.4	4.8	8.9	18.1	8.4	9.6	7.4	8.8	6.2	10.1
1967–1970	7.9	3.9	10.2	2.8	−7.1	2.9	4.2	5.8	2.6	1.2	3.8	16.0	6.4
1970–1981	10.6	12.0	9.8	11.0	5.8	11.4	11.4	12.9	13.7	16.1	13.6	8.6	9.7
1970–1975	7.9	7.8	8.2	5.3	12.4	1.8	5.1	9.6	16.8	11.7	9.0	3.1	3.9
1975–1981	12.9	15.9	11.3	16.1	.6	20.0	16.9	15.8	11.1	19.9	17.1	13.3	14.9
(Valued in 1972 dollars)													
1960–1981	4.1	4.8	3.8	5.0	−1.8	4.4	5.0	4.9	6.4	4.4	5.0	3.5	4.3
1960–1970	5.8	5.7	5.9	6.4	−1.4	5.2	7.9	5.0	5.0	3.1	5.2	6.6	6.3
1960–1967	6.5	8.5	5.4	9.9	3.3	8.6	11.9	6.9	8.1	5.1	8.1	4.8	8.3
1967–1970	3.1	−.8	6.1	−1.5	−13.4	−2.1	−.1	.8	−1.9	−3.5	−1.4	11.5	1.9
1970–1981	2.9	4.0	2.3	3.7	−2.2	3.7	4.2	4.2	5.7	5.6	5.9	1.1	2.5
1970–1975	.3	−.2	.6	−1.5	4.6	−4.5	−1.6	1.3	9.7	1.4	2.1	−2.9	−3.1
1975–1981	6.1	7.6	3.8	8.3	−7.5	11.2	9.2	6.8	3.3	9.1	9.2	3.5	7.4

NOTE.—Growth rates of PA P&E expenditures are calculated from estimates in table 5.

sources are stable over time). The calculations can be viewed as either extrapolations or as adjustments of data from overlapping sources to a consistent basis. For the chemicals industry, extrapolation was based on a linear relationship indicated by a simple regression of BEA data on McGraw-Hill data.

2. *Price indexes*

The manufacturing air PA P&E price index is a weighted average of the fans and blowers component of the Producer Price Index (fans and blowers are an integral part of many types of air pollution abatement facilities) and the *Chemical Engineering* Plant Cost Index. The *Chemical Engineering* index is itself a weighted average of components of the Producer Price Index. Weights (before adjustments) are based on profiles of spending to construct chemicals plants. Adjustments were made by BEA for differences between chemicals plants and air pollution abatement facilities.

The manufacturing water PA P&E price index is a weighted average of the *Chemical Engineering* index and the EPA Large City Advanced Waste Water Treatment Plant Cost Index or, prior to the 1973, the EPA Sewerage Treatment Plant Cost Index. For water PA P&E, adjustments to the *Chemical Engineering* index were made by BEA for differences between chemicals plants and water pollution abatement facilities.

For electric utilities, the air PA P&E price index is a weighted average of the *Chemical Engineering* index and the Handy-Whitman index. The latter is an index for public utility construction costs and contains component indexes for buildings, equipment, and materials of electric utilities. Components applicable to air pollution abatement were selected. For example, the coal and ash handling equipment component was selected for fly ash removal from electrostatic precipitators. The water PA P&E price index is a weighted average of components of the same two major indexes (as for air) and components of the Producer Price Index. Components applicable to water pollution abatement were selected. For example, the Handy-Whitman index component for reinforced concrete buildings was selected for concrete cooling tower construction costs.

Table 7.—Average Lifetimes for Air Pollution Abatement Plant and Equipment

	Years [1]
Manufacturing	
Blast furnaces	15.0
Nonferrous	14.0
Motor vehicles	20.0
Machinery	20.0
Other durables [2]	20.0
Chemicals	10.0
Paper	12.0
Petroleum	14.0
Food	10.0
Other nondurables [2]	18.0
Nonmanufacturing	
Communication, commercial, other [3]	15.0
Electric utilities	30.0
Other nonmanufacturing [3]	15.0

1. The estimates are averages for types of equipment such as baghouses, electrostatic precipitators, and wet scrubbers. Lifetimes also vary by region, plant, and process.
2. These are residual categories.
3. "Other" consists of construction; social services and membership organizations; and forestry, fisheries, and agricultural services.

The nonmanufacturing nonelectric utilities air and water indexes are weighted averages of the air and water PA indexes described above. Price changes for the PA P&E purchased were assumed to equal, on average, price changes for similar purchases by other industries.

Use of price indexes.—Constant-cost gross stocks by industry were obtained by dividing current-dollar spending by price indexes, cumulating the resulting real spending, and subtracting discards. (Discards were estimated using an assumed retirement pattern, indicated below.) To obtain net stocks, depreciation was also subtracted. Current-cost stocks were obtained by multiplying constant-cost stocks by yearend price indexes.

3. *Service lives and retirement pattern*

Straight-line depreciation, i.e., depreciation at a constant rate over the life of an asset, is used in calculating net stocks. Rates of depreciation are derived from assumed average lifetimes.

The air PA P&E lifetimes, shown in table 7, are from discussions with staff of the Industrial Gas Cleaning Institute and the Environmental Elements Corporation (subsidiary of the Koppers Corporation). The lifetimes are average physical lifetimes for types of equipment such as baghouses, electrostatic precipitators, and wet scrubbers. These lifetimes and the revised equipment lifetimes used by the EPA to provide estimates of annualized capital cost for the *Cost of Clean Air and Water Report to Congress, 1979* are of similar length.

For water PA P&E, a lifetime estimate of 80 years has been assumed for all industries. This estimate is from discussions with staff of the Koppers Corporation, the Water Pollution Control Federation, the Potomac Electric Power Company, and other industry sources. The 30-year estimate is appropriate for many mixes of equipment and structural components found in waste water treatment systems.

Data are not available on discards of PA P&E. Discards were assumed to occur symmetrically about the average lifetime, according to the modified Winfrey S-3 nonresidential retirement pattern.